Title: M & M - Mathemagical Mirrors

Brief Overview:

In this unit students will make connections between mathematics and science using technology. The lesson culminates in the application of knowledge to a real-world problem involving a child care center. By using angles of incidence and reflection, mirrors will be placed around a room so that a day care worker may see all the children at any given time.

Links to Standards:

- **Mathematics as Problem Solving**
  Students will be able to model a real-world problem. To increase the student's confidence, a variety of strategies and problem solving techniques will be incorporated.

- **Mathematics as Communication**
  Students will be able to develop a model of their real-world problem. The students will present their assessment to the class, explaining their model and why it works. The students will reflect and clarify their thinking in cooperative groups.

- **Mathematics as Reasoning**
  Students will apply spatial reasoning in relation to the mirrors and their placement. The students will validate their own thinking by demonstrating the angles and mirror placement within the classroom.

- **Mathematical Connections**
  Students will apply mathematical thinking and modeling to solve problems that arise in a science classroom. The students will see mathematics as an significant part of our world, culture, and everyday life.

- **Patterns and Functions**
  The students will model a real-world occurrence recognizing a graphical representation.

- **Geometry**
  Students will create a two-dimensional model on the computer and a three - dimensional model in the classroom to test their conjectures. The students will apply geometric properties and develop an understanding of their investigation.

- **Measurement**
  Students will measure the angles of incidence and reflection to solve their problem. These measurements validate conjectures and prove to students the need for accurate measurements.

Grade/Level:

This unit is recommended for use with students taking geometry and physical science. This unit is intended for eighth grade students.

Duration/Length:

This unit will take approximately 5 days in math classes and 5 days in science classes.

Prerequisite Knowledge:

Before beginning this unit students should be able to:

- Identify and measure angles
- Identify parallel and perpendicular lines
- Explain the wave model of light
- Describe the characteristics of an electromagnetic wave

Objectives:

Upon completion of the unit the student will be able to:

- identify and measure the angle of incidence and the angle of reflection of a light wave.
- solve problems and give appropriate support for solutions.
- predict the pathway of light .

Materials/Resources/Printed Materials:

- Dot paper
- Mirror
- Flashlight
- Drawing software program such as, Geometer's Sketch Pad
- Donald Duck in Mathemagic Land video
- Student worksheets
- Teacher masters

Development/Procedures:

Note: Allow students to form their own groups of 2-4 people.

Day 1:

Math	Within Donald Duck in Mathemagic Land video, there is a real-life example of billiards demonstrating angle of reflection. This is an appropriate introduction to this mini unit. After the introduction, the students could be taken to the computer lab and can practice forming angles and measuring angles. Please refer to your computer lab and the software programs you have available.
Science	Refer to Problem solving lesson
Distribute	Assessment

Day 2:

Math	On day two, students would use the computer to further explore marked vectors and angles. Please use the programs available at your school.
Science	Refer to Reflectivity of light lab

Day 3:

Math	Refer to blueprint for day three and construct the model of the floor plan using the software available.
Science	Review rubric: Bubbles Child Care Center. Have students post blueprints from computer program used in math class and complete the cooperative learning activity Gallery Walk.

Day 4:

Math	Build a three-dimensional model of the day care center
Science	Build a three-dimensional model of the day care center
Homework	Complete a written prompt justifying the model.

Day 5:

Math	Evaluation: prompt on model revisions
Science	Evaluation: present models and justifications

Performance Assessment:

The assessment for this unit is the Bubbles Child Care Center challenge. The assessment is graded using the rubric which will be distributed on the first day.

Extension/Follow Up:

Some suggested ideas for extension /follow up are:

- Guest speaker from Child Care Agency
- Guest speaker from NSA to talk about math, science connections in the real-world

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SCIENCE LESSON ONE: DEFINING THE PROBLEM

OBJECTIVES: Upon completion of this activity, the student will demonstrate the ability to:

- Distinguish between an exercise and a problem.
- Define the problem of this lesson.
- Brainstorm information needed to solve the problem.

LESSON INFORMATION:

1. An exercise is a question that can be answered because there is no gap between what we already know and what we have to know to answer the question. A person can either solve an exercise easily or at least have a good idea of how to go about seeking a solution. Exercises provide us with valuable information they do not necessarily provide us with new ideas or new solutions. Here are some examples of questions that may be considered exercises.

How do you make a cake?
What is 25 X 25?
How do I make a graph?

2. When there is a gap between what we know and what we need to know to answer a question we have a problem! Because our knowledge is incomplete we need to spend time filling in the gaps before attacking the problem. With problems the solution is not always clear and more than one solution is usually suitable. The solution to a problem not only provides us with new solutions but also new methods of obtaining these solutions. Here are some examples of problems.

What happens to the taste of a cake if I remove one ingredient?
How can I increase the probability that I do better on the next science test?

3. Use Science Activity Sheet Day One: Characteristics of Exercises and Problems, to identify the characteristics of problems and exercises.

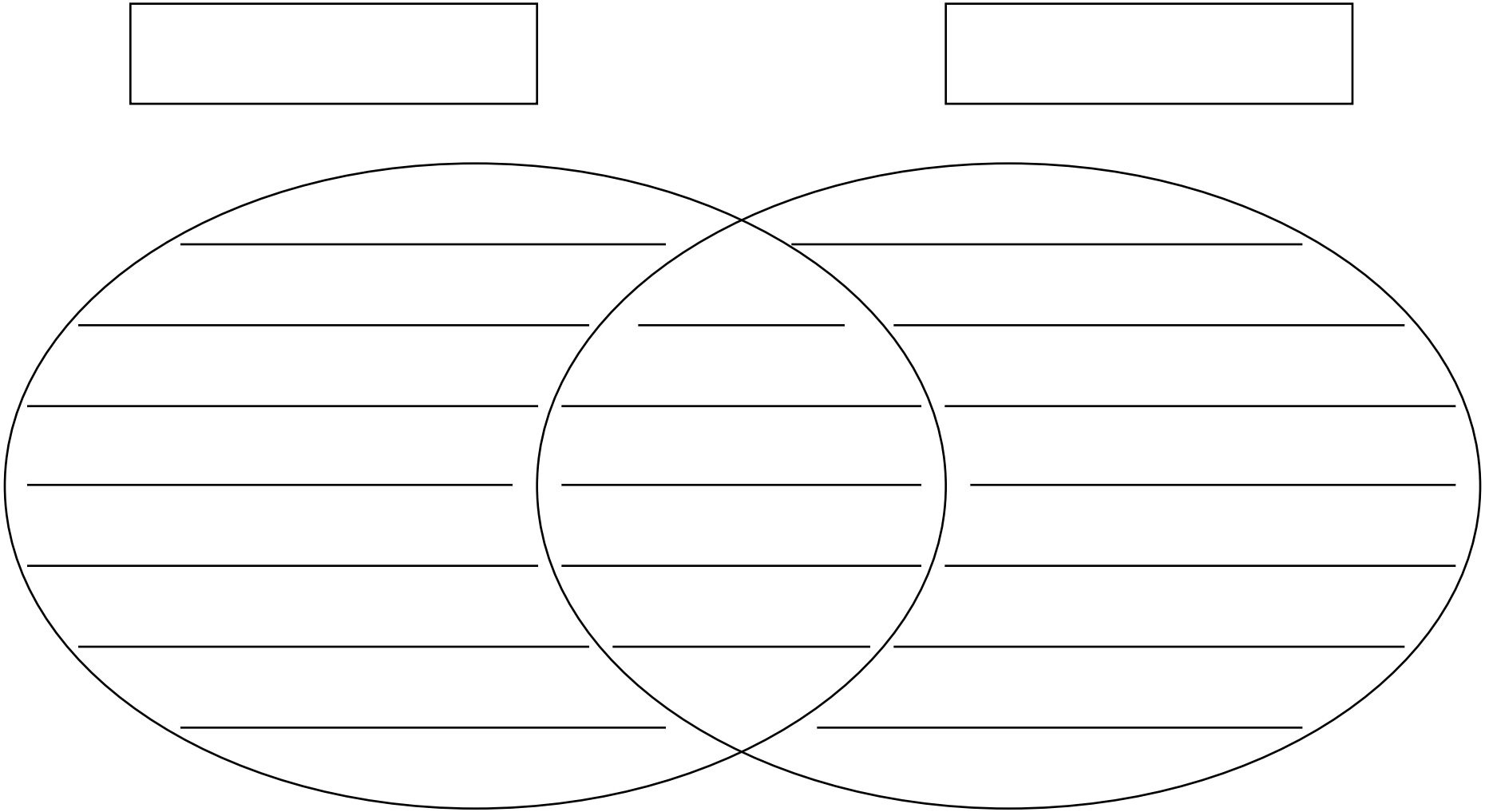
4. In this lesson you and your group will attempt to solve a problem. Bubbles Child care Center has hired only 1 person to supervise 10-15 children between 5:00 p.m. and 6:00 p.m. Your group will be given the floor plan of the center. You will also be given any number of mirrors the group feels will be necessary, however, you have a budget of $50.00. Each 8” x10” mirror costs $10.00 and, due to safety regulations, the mirrors can not be altered in any way. Your problem is to determine where you can place the mirrors and where the child care worker should position himself in order to observe all of the children all of the time.

5. Use Activity Sheet two: Know-Need-Learn, to help groups identify what is already known and what information is needed to solve this problem.

Science Activity Day One
Comparing the Characteristics of Problems and Exercises

Directions: Compare the characteristics of problems and exercises by completing the graphic organizer (next page). Suggested answers are provided here for the teacher:

When doing an EXERCISE you:	**When solving a problem you:**
1. follow the directions.	1. invent the directions.
2. always arrive at the same answer.	2. may arrive at different answers.
3. have only one best answer.	3. may have more than one best answer.
4. use only the information given.	4. seek out all the necessary information.
5. make corrections to an incorrect solution.	5. make modifications when original plans do not work as planned.



WHAT I...

KNOW	NEED TO KNOW	LEARNED

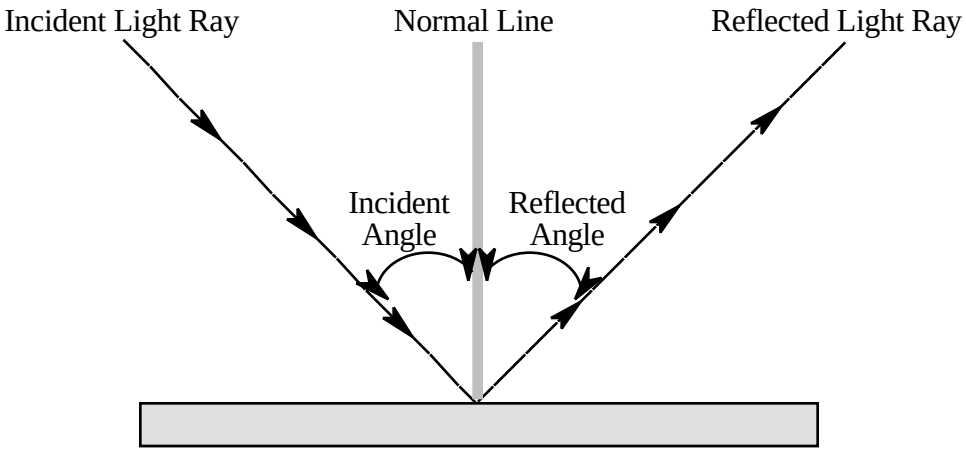
REFLECTION LAB

Name _____
Date _____ Class _____

Introduction

Light rays travel in straight lines. The light seen coming from most objects is made up of reflected light. Reflected light is light that is bounced off the object it strikes. A smooth surface, such as a mirror, will reflect light rays.

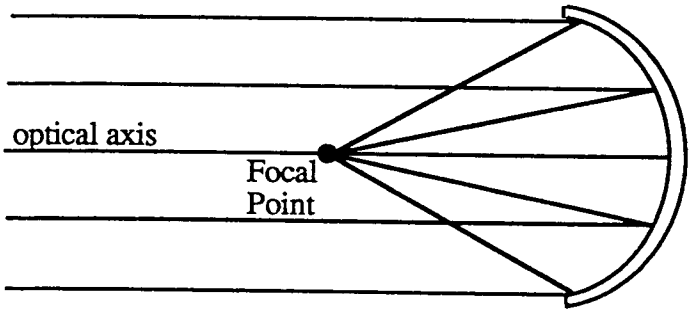
The ray that is incoming (hits the surface) is called the incident light ray. The reflected light ray is the ray that bounces off the surface. The normal line is the line that forms a right angle to the surface. The angle of incident is the angle between the normal line and the incident light ray. The angle of reflection is the angle between the normal line and the reflected light ray. The law of reflection states that the angle of incidence is equal to the angle of reflection.



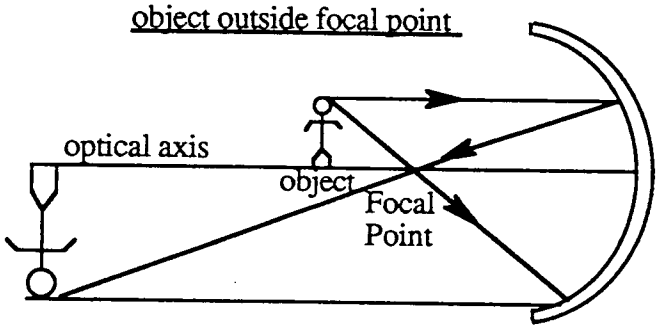
The law of reflection is true for concave and convex mirrors also. The line through the center of these mirrors is called the optical axis. The focal point is the point through which all rays parallel to the optical axis are reflected. The focal length is the distance between the focal point and the mirror surface. Real images are formed in front of the mirror and can be projected on a screen. Virtual images are formed behind the mirror.

REFLECTION LAB

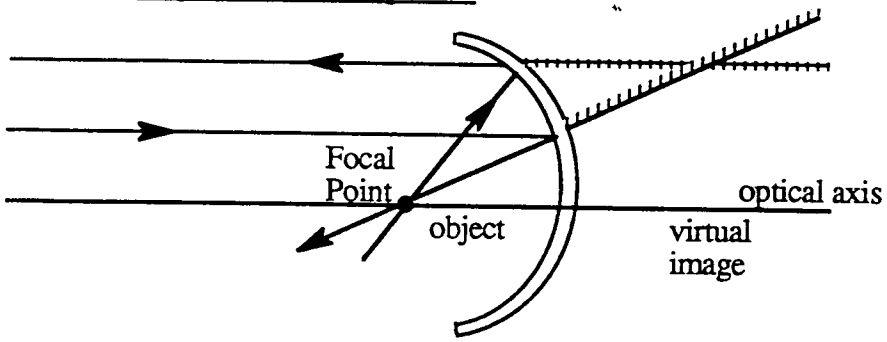
Concave Mirror



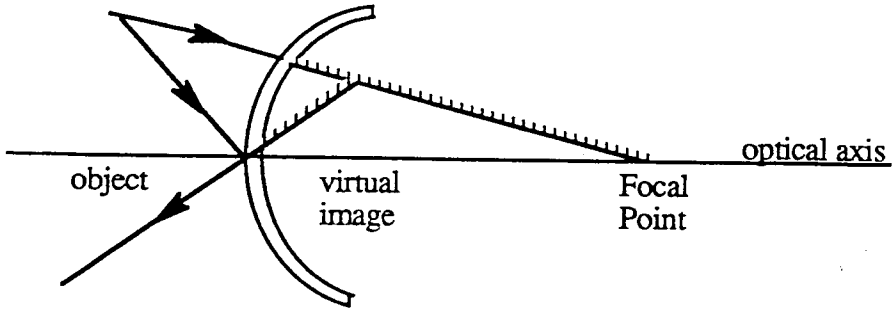
object outside focal point



object inside focal point



Convex Mirror



REFLECTION LAB

Objectives: Upon completion of this activity, the student will demonstrate the ability to:

1. Use terminology of light reflection
2. Draw the reflected ray from a plane mirror
3. Measure the angle of incidence and the angle of reflection
4. Describe or diagram how a plane mirror appears to change the image
5. Produce real and virtual images using a concave mirror
6. Describe changes in the images seen in a concave mirror
7. Describe the image produces using a convex mirror.

Materials

- ruler
- plane mirror
- concave mirror
- convex mirror
- unlined paper
- protractor
- string
- tape

Procedure

A. Plane mirror

1. Draw a straight line parallel to and about 1 cm from the edge of the paper.
2. Use a the protractor and draw a line through the middle of the paper that is perpendicular to the first line. The is the norm or normal line.
3. Carefully draw a third line that intersects with the other two lines at the point at which they cross. This third line represents the incident ray line.
4. Tape the piece of thread to the back and middle of one edge of the mirror so that most of the string protrudes from the reflective side of the mirror.
5. Place the mirror on the side to which the thread is attached. Align this mirror edge parallel to the line you drew parallel to the edge of the paper. Move the mirror along the string can be stretch directly over the line drawn perpendicular to the line parallel to the edge of the paper. (This stretches the thread over the normal line.)
6. Move the string away from the normal line until it forms a straight line with the reflection of the incident ray. Mark the position of the string with a dot.
7. Remove the mirror. Using the ruler, draw a straight line connecting the dot in procedure 6 to the point that is common to the other 3 lines. This new line represents the reflected light ray.
8. Measure and record the angle of incidence and angle of reflection.
9. Repeat steps 1-8 on the back of the sheet of paper using a different angle of incidence.
10. Look into the mirror so you can see your mouth, and move your tongue to the left corner of your lips. Observe. The move your tongue to the right corner of your lips. Observe and record all observations. Face you lab partner and observe as he/she moves his/her tongue as directed above. Record observations.

REFLECTION LAB

B. Concave Mirror

1. Hold the concave mirror about 6 cm from your face. Move it to focus on your mouth. Repeat procedure 10 above and record observations.
2. Gradually move the mirror away. Observe what happens to the image. Record.
3. Continue moving the mirror away until another image appears. Record how this image differs from the image in B-1.

C. Convex Mirror

1. Hold the convex mirror about 8 cm from your face. Repeat tongue movement in procedure A-10. Record observations.
2. Gradually move the convex mirror away from you. Observe any change you can see in the image. Record your observations.

Observations/Data

Plane Mirror

	Angle of Incidence	Angle of Reflection
Trial I		
Trial II		

Procedure 10:

Concave Mirror

#1

#2

#3

Convex Mirror

#1

REFLECTION LAB

Analysis of Data

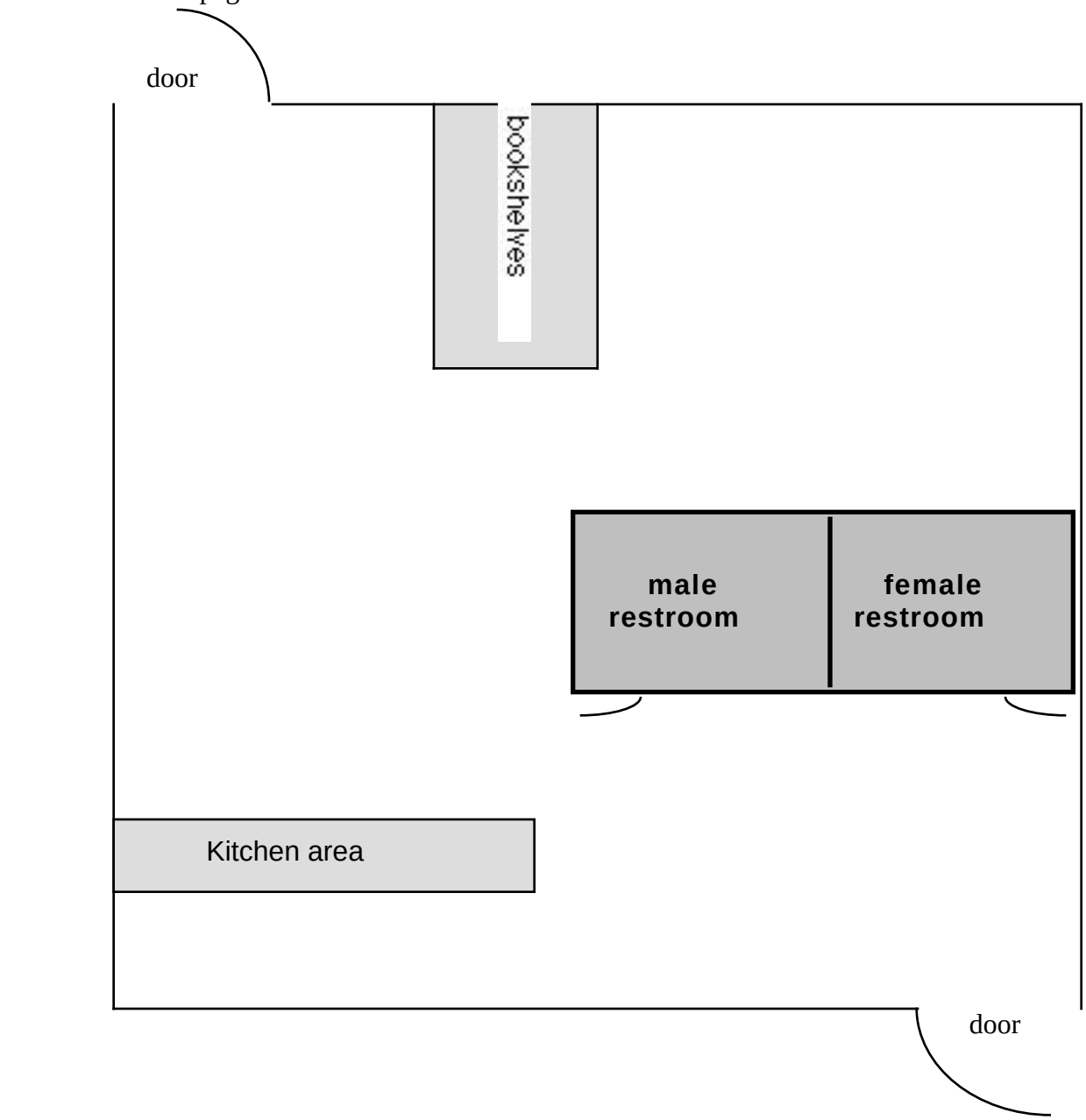
1. How does the angle of incidence relate to the angle of reflection?
2. Which mirror(s) formed virtual images?
3. Which mirror(s) formed real images?
4. Which mirror(s) magnified the object?
5. Which mirror(s) made the object appear the same size?
6. Which mirror(s) made the object appear smaller?

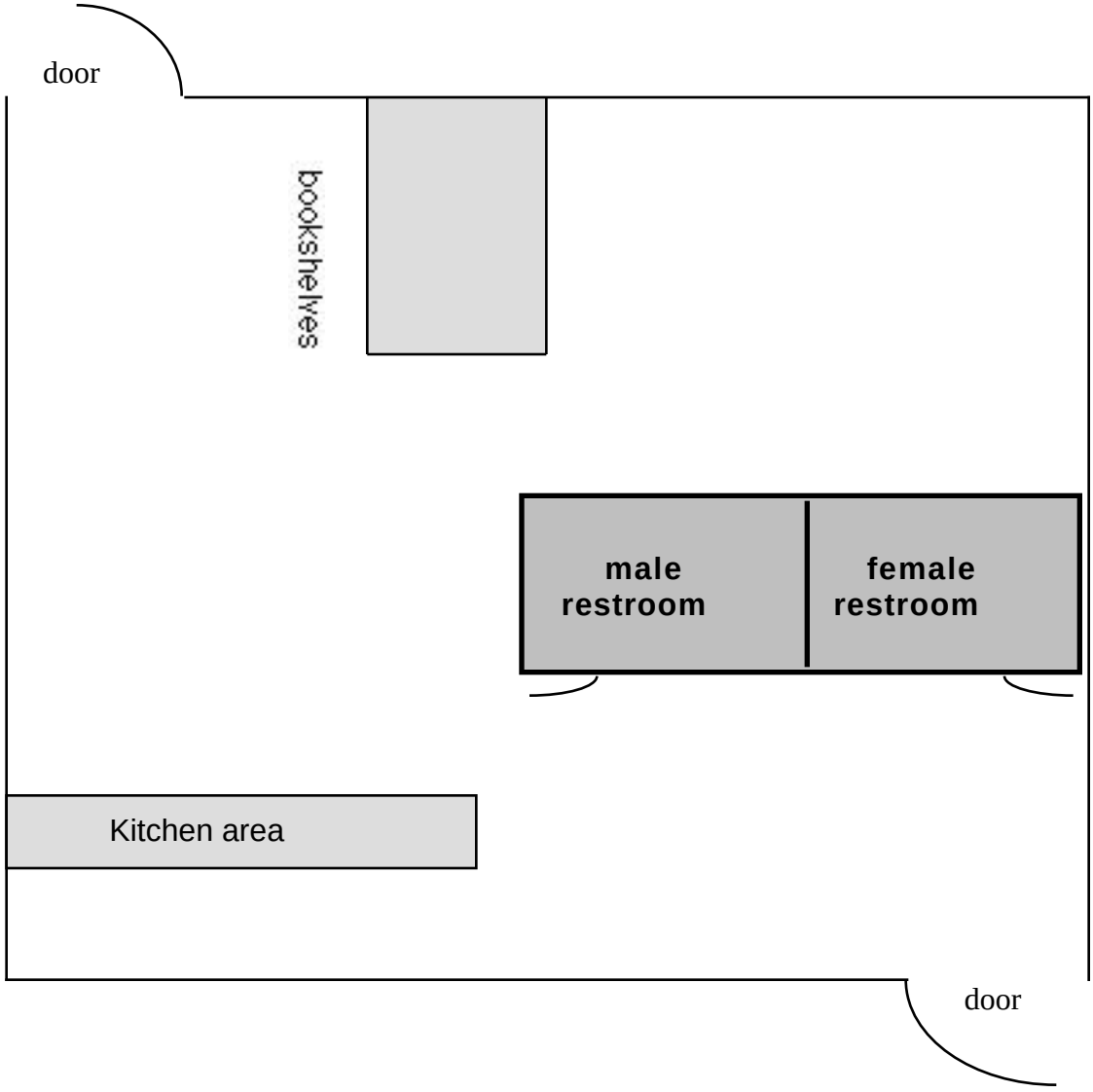
Conclusion

1. Compare the images formed in the plane mirror, the concave mirror, and the convex mirror.
2. What relationship exists between the size of the image and the distance from the mirror for each type of mirror?
3. Which mirror(s) form an upside down image? Under what conditions?
4. Which mirrors reverse right and left? Under what conditions?

Assessment

Bubbles Child Care Center hired only one person to watch the children for the last hour of child care.There are normally 10 - 15 students left for that last hour. You have a budget of $50.00. Each 8" x10" mirror costs $10.00 and, due to safety regulations, the mirrors can not be altered in any way. The cost includes mounting the mirrors to the wall. Your problem is to determine where you can place the mirrors and where the child care worker should position himself/herself in order to observe all of the children all of the time. The floor plan of Bubbles Child Care Center is shown at the bottom of the page.




door
bookshelves
male restroom
female restroom
Kitchen area
door

RUBRIC: BUBBLES CHILD CARE CENTER

5 The student demonstrates an in depth understanding of reflections and their application to the given situation. The explanation concernin the appropriateness of the given plan is accurate and articulate, and t student may offer additional insights. (For example, the student may identify the entire range of points that are not visible to the person). model and essay show evidence of careful thought, and may be rendered imaginatively.

4 The student demonstrates a clear understanding of reflections and their application to the situation. The student presents a valid argum as to why the given plan is appropriate, but it may contain minor erro The model is appropriate, and the essay is well-organized and easy to read, but one or both may lack some detail.

3 The student demonstrates a fundamental understanding of reflections and their application to the situation. The student recogn that the given plan is inappropriate, and may make a major error in justifying the conclusion. The rendering of the model and the essay ma be inaccurate.

2 The student demonstrates some understanding of reflections, but needs assistance in applying the concepts and properties to the given situation. Even with help, the student may make major errors in analy their plan. The student's model and essay may be jumbled and incomple

1 The student demonstrates little if any understanding of reflectio and is unable to apply them to the given situation. The student may attempt to analyze their plan, but any observations are superfluous and irrelevant. The student may simply copy or restate the given informat

Lab Summary

The child care licensing agency will be visiting Bubbles Day Care Center tomorrow to evaluate your group's plan. If your plan is acceptable, the agency will grant the Day Care Center its license and the center can be opened for business. If the plan is not acceptable, the license will not be granted until the suggested modifications are implemented.

Before you begin your explanation, think about why you chose the number and placement of mirrors in your plan. Think about how you could use the information of the angles of reflection and incidence you measured in the lab to support your placement of mirrors. Think about how your model is the most economical way to meet the state standards.

Now, write a full explanation that describes the details of your model. For each mirror you have mounted identify the angle at which it has been mounted, the angles of incidence (from the area to be viewed), and the corresponding angles of reflection (from the mirror to the person). Be sure to include a justification for the placement in terms of the possible range of visibility. Finally, include a justification of how your plan is the most affordable method.

Identify:

F

A

T

P

Create your web or outline below:

Use your web/outline to write your response on a separate sheet of paper.

Reflecting on Our Work- Journal Entry

Take a few minutes to critically evaluate your design for Bubbles Child Care Center. Think about an area that your group found most challenging, but were successful in placing mirror(s) to view children. Think about what made the area challenging. Think about the way your group resolved the placement of the mirror(s). Think about an area where visibility was limited. For example, the areas where the group felt the view of one area had to be compromised in order to see into another areas. Think about the way your group resolved the placement of the mirror(s).

Now , write an informative essay for your teacher in which you discuss how your group worked to resolve one specific problem area of your model. First, clearly identify why this area was a problem for your group. Next, specify how your group resolved these problems. Finally, justify your degree of agreement or disagreement with your group's resolution.